

P-10.4 Explain thermal expansion in solids, liquids, and gases in terms of kinetic theory and the unique behavior of water.

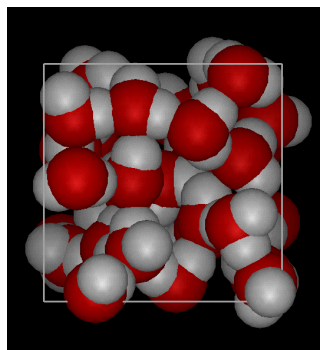
Revised Taxonomy Levels 2.7 B Explain conceptual knowledge

In physical science, students

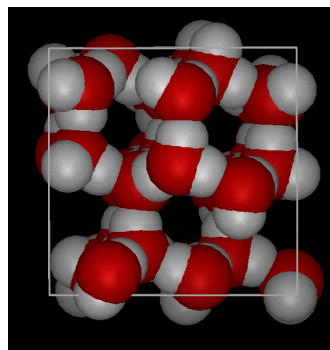
- ❖ Compare the properties of the four states of matter—solid, liquid, gas, and plasma—in terms of the arrangement and movement of particles. (PS-3.6)
- ❖ Explain the processes of phase change in terms of temperature, heat transfer, and particle arrangement. (PS-3.7)

It is essential for students to

- ❖ Understand the two basic concepts of the kinetic theory
 - The molecules of a substance are in constant motion
 - The amount of motion depends upon the average kinetic energy of the molecules; this energy depends upon the temperature.
 - Collisions between molecules are perfectly elastic (except when chemical changes or molecular excitations occur).
- ❖ Explain thermal expansion in solids both conceptually and mathematically
 - The change in length of a solid equals the product of its original length, its change in temperature, and its coefficient of linear expansion.
 - For the same increase in temperature, different materials of the same length expand by different amounts (depending upon the nature of the molecules which comprise the materials)
 - The coefficient of linear expansion is a value which indicates the change in length per unit length of a solid when its temperature is changed one degree
 - $\Delta\ell = \alpha \ell \Delta T$ where
 - $\Delta\ell$ = the change in length
 - α = the coefficient of linear expansion
 - ℓ = the original length
 - ΔT = the change in temperature
- ❖ Explain how the combined effects of molecular motion and crystalline structure result in water being the most dense at a temperature of 4°C.



Structure of liquid water



Structure of ice

❖ Explain the expansion of gasses in terms of Charles' Law

➤ $V' = VT_k'/T_k$ Where

- ◆ V' = The new volume of a gas
- ◆ V = The original volume of a gas
- ◆ T_k' = The new temperature (Kelvin)
- ◆ T_k = The original volume (Kelvin)

Assessment

The verb, explain means that the major focus of assessment should be for students to “construct a cause and effect model”. In this case, assessments will ensure that students can model the thermal expansion of substances, in terms of the kinetic theory. Because the indicator is written as conceptual knowledge, assessments should require that students understand the “interrelationships among the basic elements within a larger structure that enable them to function together.” In this case, assessments must show that students can construct a cause and effect statement relating how temperature affects the kinetic energy of the particles of substances in various phases and how the change in kinetic energy affects the volume of the substance.